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Aedes albopictus in northeast Mexico: An update on adult distribution and first report of parasitism by *Ascogregarina taiwanensis*

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ABSTRACT

Background & objectives: Aedes albopictus has been known as efficient vector of dengue in Asian countries and its wide displacement of *Ae. aegypti* has been documented in many parts of the world. The present survey was carried out to update the distribution of *Ae. albopictus* in northeast Mexico and to report the first record of parasitism of mosquitoes by *Ascogregarina taiwanensis* in Mexico.

Methods: Human landing collections were conducted in the month of May every year between 2007 and 2009 across the three states, Nuevo Leon (NL), Tamaulipas and Coahuila in northeast Mexico. Six human bait collections were also organized at the cemetery of Gomez Farias (GF), a village in southern Tamaulipas during the rainy and dry seasons in 2010. *Aedes albopictus* caught in 2010 were dissected for parasitic protozoan gregarines.

Results: The results of human landing collections carried out during 2007–10 across the three states of northeast zone of Mexico revealed that *Ae. albopictus* is invading along the route between Monterrey City in NL and Tampico, Tamaulipas, but not into the arid state of Coahuila. *Aedes albopictus* was recorded in nine new municipalities in addition to the 15 municipalities reported before 2005. Furthermore, six human-bait collections performed during the dry and rainy seasons in 2010 at the cemetery of GF suggest the exclusion of *Ae. aegypti* on that site. Dominance was shared by *Ae. quadrivittatus*, another container-inhabitant but indigenous species, and *Ae. albopictus* during the dry and rainy seasons, respectively. The results of dissection of the mosquitoes for gregarines revealed the parasitism of *Ae. albopictus* by *A. taiwanensis*.

Interpretation & conclusion: The results of this study showed that *Ae. albopictus* has spread to all the municipalities in the northeastern Mexico except the arid area and reported the first record of parasitic protozoan *A. taiwanensis* in Mexico. We recommend further studies on larval and adult populations of natural container-occupant mosquitoes in northeastern Mexico in order to have a better documentation of the impact of *Ae. albopictus* upon the indigenous species community, and its epidemiological role in dengue transmission.

Key words *Aedes aegypti; Ae. albopictus; Ae. quadrivittatus; Ascogregarina taiwanensis;* distribution

INTRODUCTION

Aedes albopictus (Skuse) is a native of South Asian countries where it has been reported as efficient transmitter of dengue fever[1]. It is known as a cosmopolitan mosquito due to its strongly invasive nature[2]. In USA, it was first reported in Houston, Texas[3] from where it spread north and eastwards affecting populations and distribution of container-occupant species, such as *Ae. aegypti*[4]. Although, the competition between *Ae. aegypti* and *Ae. albopictus* has been investigated[5–6], it is still difficult foreseeing the spatial mosaic of sympatric or allopatric scenarios in habitats of *Ae. aegypti* invaded by *Ae. albopictus*[7]. Both the species are attracted to shady places but the former is highly anthropophilic preferring urbanized habitats while the latter is more zoophilic that lives in woody rural habitats around residences[8]. These behaviours make them to coincide in cemeteries where mosquito ecologists have documented better their competition. Some studies have reported the exclusion in favour of *Ae. albopictus*, while in other reports coexistence has been the outcome[9–10].

Following the record of *Ae. albopictus* in USA, larvae were found for the first time in tires in the arid state of Coahuila, Mexico, at the border cities of Piedras Negras and Ciudad Acuña[11]. Few months later in the same state, larvae were collected in tires at Melchor Muzquiz, a city near to the border[12] and subsequently the larvae and adults at Reynosa, a sister city of McAllen, Texas[13]. Therefore, *Ae. albopictus* invaded Mexico across its border with USA[14–15]. In the last five years, the newly invaded range has not been reported including the south of Tamaulipas

with subtropical climate and wooded area conducive for the survival of *Ae. albopictus*.

In the three states encompassing the northeastern Mexico, *Ae. aegypti* is the dominant species involving in the transmission of dengue fever. The outbreak of the infection had been reported in Nuevo Leon (NL) and Tamaulipas, which had a combined morbidity rate of more than 10,000 cases during the last decade (Orta-Pesina, Personal communication). Even though *Ae. albopictus* is competent for dengue serotypes 2 and 3 in Mexico[16], its current geographical distribution, relative population of host-seeking females and the possible existence of parasitic gregarine in northeastern Mexico have not been documented. Gregarines usually reduce the fecundity and reproductive potential of female mosquitoes and could be explored as biocontrol for mosquito control strategies. Here, we present an update of its distribution in this zone through survey made using human landing captures. We also report the dominance shared with the indigenous *Ae. quadrivittatus* in a locality where *Ae. aegypti* had apparently disappeared, and document the first record of parasitism by *A. taiwanensis* (Lien and Levine) (Apicomplexa: Lecudinidae) for Mexico and central America.

MATERIAL & METHODS

The host-seeking female mosquitoes were collected through human landing method in the municipalities sideward the main road ("carretera nacional" as in Spanish) from the metropolitan zone of Monterrey, NL and Tampico, Tamaulipas in northeastern Mexico and all the localities were geo-referenced. At each referenced point, human-landing collection was organized in May of each year, including the cemetery of the municipality Gomez Farias (GF), Tamaulipas between 2007 and 2009. The field studies were conducted during once in the month of May as these represented the transition period of the year between dry and wet seasons, though this line is variable because the climate change. Therefore, in the month of May (end of dry season) occurs the most adverse climate conditions for mosquitoes breeding in artificial or in temporary natural vessel sites such as epiphytic bromeliad axils, hence, the competence and survivorship of the mosquitoes is stronger. The collection was made at the same site in each locality throughout the period of the study. In addition, we carried out six human-landing collections during 2010 at the same cemetery (25° 02′ 49.24″ N, 99° 09′ 32.21″ W). The adult collections in the month of May of 2007 to 2009 were done to monitor the presence of *Ae. albopictus* in the municipalities along the road. The collections at GF in 2010 were to estimate the relative abundance of adults of commonest species and explore the impact of *Ae. albopictus* upon *Ae. aegypti* and other indigenous container-occupants during the dry season (March–July) and the wet season (August–October) in 2010.

Each human-landing collection consisted capturing all the mosquitoes that landed on the legs and arms of four persons (the authors) during a two-hour interval at sunset (1800 to 2000 hrs). A mouth aspirator was used and the mosquitoes caught were placed in vials for subsequent identification with morphological keys[17–18]. The Malpighian tubules of all the *Ae. albopictus* collected were dissected immediately after their capture in 0.75% saline solution under a 400× microscope magnification, in search of autochthonous parasitism by *A. taiwanensis*. Total females per mosquito species plus parasitism rates by *A. taiwanensis* were recorded per sampling.

RESULTS

Human-landing collections conducted in May in each geo-referenced municipality between 2007 and 2009 along the road Monterrey-Tampico showed that *Ae. albopictus* is now present in nine municipalities in addition to 15 municipalities recorded before 2005. A map covering three states of the region is shown in Fig. 1. The new municipalities include Monclova (26° 54′ 36.43″ N, 101° 24′ 57.71″ W) in the State of Coahuila, Benito Juarez (25° 31′ 58.45″ N, 100° 05′ 01.73″ W) in NL, Ciudad Victoria (23° 45′ 11.33″ N, 99° 59′ 58.01″ W), Xicotencatl (22° 59′ 45″ N, 98° 56′ 41″ W), Ciudad Mante (22° 44′ 39.74″ N, 98° 58′ 30.27″ W), Altamira (22° 24′ 7.13″ N, 97° 56′ 12.15″ W), Ciudad Madero (22° 16′ 32.02″ N, 97° 50′ 22.25″ W), and Tampico (22° 18′ 9.98″ N, 97° 51′ 58.74″ W) in the State

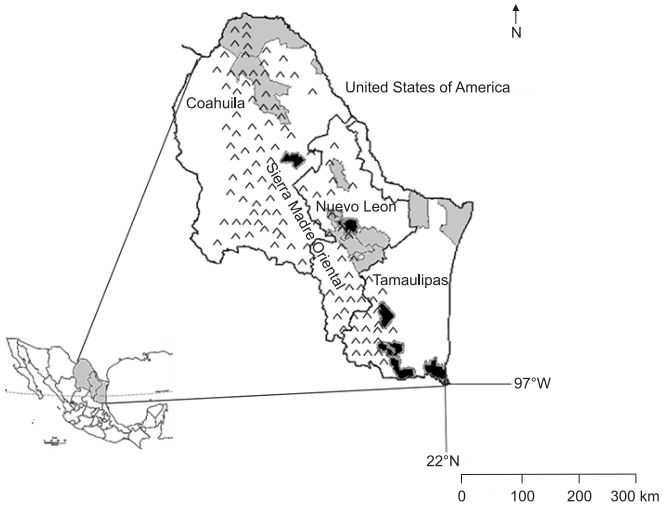

Fig. 1: Map of northeastern Mexico with the geographical distribution of *Aedes albopictus*. The municipalities in grey were invaded before 2005, and the black were newly invaded areas.

of Tamaulipas. *Aedes aegypti* was caught throughout the period of the survey between 2007 and 2009 at GF cemetery. *Aedes albopictus* was absent in 2007 but caught for the first time in 2008 and later in 2009 where its population was higher than *Ae. aegypti* (13 *Ae. aegypti* and 34 *Ae. albopictus*) at the cemetery.

However, of 290 host-seeking female mosquitoes captured in six collections performed during the dry (March 30 and 31) and rainy season (July 28 and 29, September 25, and October 14) of 2010 at the cemetery. *Aedes albopictus* accounted for 89 (31%), while *Ae. aegypti* was not caught during the sampling period. The remaining 201 female mosquitoes belong to *Ae. quadrivittatus* (123), *Ae. amabilis* (35), *Wyomyia mitchellii* [Debe Ser Mitchellii] (28), *Culex quinquefasciatus* (6), *Ae. trivittatus* (5), *Ae. podographicus* (2), *Psorophora ferox* (1), and *Haemagogus equinus* (1) (Fig. 2). None of the females of *Ae. albopictus* caught in the dry season had the parasite of *A. taiwanensis,* however, 15 (18%) out of 82 females dissected in the wet season were positive for the gametocytes and oocysts of this protozoan.

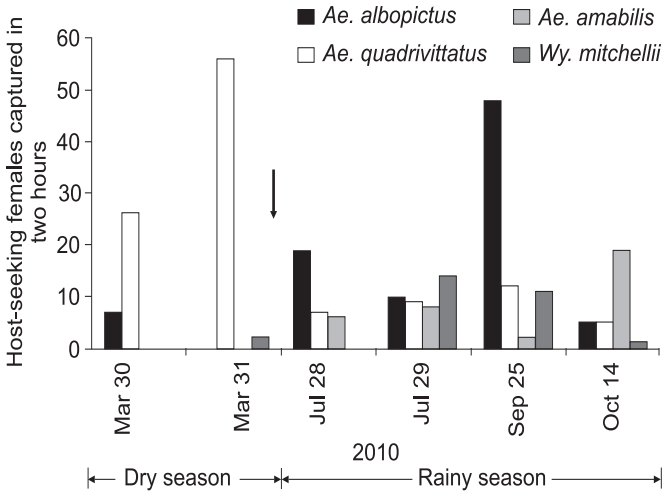

Fig. 2: Relative abundance of mosquito species at the cemetery of Gomez Farias in northeast Mexico. Mosquito catches were conducted in May (arrow) due to the end of the dry season, when the competition and survival of mosquitoes in the larval breeding sites is stronger.

DISCUSSION

Aedes albopictus populations are well-established in the States of NL and Tamaulipas but not in Coahuila, encompassing the three of the states in northeast Mexico. Nine municipalities: two for NL and the rest for Tamaulipas are reported in this survey as newly invaded localities after 2005. The addition of these nine new municipalities with 15 earlier reported before 2005 showed that the vector has been found in 24 municipalities of the region. The road ("carretera nacional" as in Spanish) from Monterrey, NL to Tampico, Tamaulipas is a natural geographical corridor for the spread of the *Ae. albopictus* because it is parallel to the Sierra Madre Oriental and virtually all the settlements are in arboreal and shady areas. This climatic picture would have probably facilitated the dispersal of *Ae. albopictus* largely into NL and Tamaulipas which has been known to prefer woody environment[2].

Furthermore, large stocks of used tires are imported illegally from USA[19]. The used tire trade has been declared responsible for worldwide dispersal of *Ae. albopictus*[1, 20] and northeast Mexico is no exception. The trade is intense at Reynosa and Matamoros through the border, and between these cities of Tamaulipas and the metropolitan zone of Monterrey, NL, whose population (~4 million of people) is superior than to the one (~3.2 million) of the entire state of Tamaulipas. In contrast the NL which is highly industrialized, the southern Tamaulipas has an economy based on agriculture and livestock where farmers commonly buy second hand tires. Unfortunately, there are no facilities for legal disposal of discarded tires in Mexico, and disused tire dumps have proliferated along the route from Monterrey to Tampico, possibly generating habitats favourable for the arrival and establishment of *Ae. albopictus.* Although *Ae. albopictus* is less competent than *Ae. aegypti* for dengue, the vertical transmission of the virus has been reported in insects[2]. Its presence would, therefore, complicate the epidemiological scenario of dengue in rural habitats and small cities in northeast Mexico. Our collections at GF cemetery during 2010 suggest a probable displacement of *Ae. aegypti* by *Ae. albopictus* and perhaps the same scenario is progressing in other ecologically similar villages at the south of Tamaulipas.

Given the subtropical characteristics and abundance of rural habitats, it could be speculated that the distribution of *Ae. aegypti* and *Ae. albopictus* in the southern Tamaulipas will be similar to the situation reported in Florida, USA[21]. The residents of *Ae. aegypti* will prevail in the urban habitats living in peridomestic areas and inside the houses, while *Ae. albopictus* will be commonly found in wooded areas of cities, towns and villages, such as cemeteries, where it will be excluding or coexisting with the primary dengue vector.

It is remarkable to report for the first time, the record of parasitism of mosquitoes by protozoan *A. taiwanensis* in Mexico. Previous studies had shown that the parasite had been reported in Illinois[22], Louisiana[23], and Florida[24] all located in USA. It has also been detected in Brazil[25], but so far no record of its existence in Mexico before this study. The parasites play an important role in biocontrol

of mosquito vectors and its adaptation in *Ae. albopictus* which could be explored for its control in future studies.

In conclusion, the present study has described the current distribution of *Ae. albopictus* in northeastern Mexico and its route of incursion into the area. We have also reported the probable displacement of resident *Ae. aegypti* by *Ae. albopictus* and, in addition reported the first record of parasitic protozoan *A. taiwanensis* in Mexico. Further studies with larval and adult populations of natural container-occupant mosquitoes in northeastern Mexico are necessary, to have a better documentation of the impact of *Ae. albopictus* upon the indigenous species community, and of its epidemiological role for dengue.

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